Tracing magma sources of three different peraluminous granitoid series by in situ U–Pb geochronology and Hf-isotope zircon composition

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Abstract

Three distinct S-type peraluminous granitoid types have been identified within a Variscan batholith located in the Central Iberian Zone (SW European Variscides), the Montes de Toledo batholith: type-1, extremely high peraluminous restite-rich granitoids; type-2, highly peraluminous restite-bearing granitoids; and type-3, moderately peraluminous granitoids with mafic microgranular enclaves. Each peraluminous series followed distinct evolution paths through progressive crystal fractionation. U-Pb geochronology reveals that the batholith formation extended for about 19 Ma between 316 and 297 Ma. Although the degree of peraluminousity of the different series could be related to different partial melting conditions or to the variable entrainment of restitic components, whole-rock geochemical signatures and isotope zircon composition of the peraluminous granitoid types suggest contribution of different crustal sources. Type-1 and type-2 granitoids contain mostly Archean to Neoproterozoic inherited zircons, whereas type-3 granites show preferentially Neoproterozoic (up to late Cryogenian) and Ordovician inheritance. The wide range of initial Hf isotope composition, ranging to highly radiogenic values (ƐHf up to +10), of Neoproterozoic zircon inheritances in type-1 and type-2 granitoids suggests derivation from heterogeneous Neoproterozoic metasedimentary sources composed of both juveline and recycled crustal materials, similar in composition to the host Schist-Greywacke Complex metasediments. Nevertheless, the highly negative initial Nd isotopic signature measured in some type-1 granitoids ($ƐNd_{300}$ up to –9.4) also suggests a contribution of more mature metasedimentary sequences, such as those described in the northern Central Iberian Zone. On the contrary, the high Ca, Na and Sr bulk-rock contents in type-3 granitoids, together with the presence of Ordovician magmatic inherited zircons, and the absence of inheritances older than Cryogenian ages, suggest the involvement of a metaigneous protolith. This conclusion is also supported by the similar mean whole-rock $ƐNd_{300}$ isotopic values, T_{DM} ages and ƐHf isotope zircon composition of type-3 granitoids when compared to data from outcropping augen orthogneisses from Central Spain. These results not only indicate that the implication of metasedimentary and/or metaigneous sources contributes to enhance geochemical and isotopic differences in S-type peraluminous granitoid series in intracontinental orogenic settings, but also fractional crystallisation processes are responsible of the geochemical variability through the evolution of these felsic magmas.

Keywords: U–Pb geochronology, Hf isotope zircon composition, peraluminous granites, Montes de Toledo batholith, Iberian Variscan Belt S-type granitoid magma sources